ON THE USE OF AN ELECTRO-MAGNET FOR REMOVAL OF A FOREIGN BODY FROM A BRONCHUS.

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On March 31, 1904, a female child sixteen months old, while lying on its back on the nurse's lap playing with a shingle-nail, was observed to suddenly strangle and cough severely, and the nail had disappeared. The mother was away from home, and did not return for about half an hour. The child coughed considerably, but before the mother's return had eaten a good meal of bread and milk, and was in good condition except an occasional cough and a wheezing respiration. Dr. E. G. Gowen was at once called. Dry food only was given for three days, and during the week the child was treated for bronchitis. The symptoms remained about the same for the week, except the coughing was more frequent and severe.

The child was brought to me April 7. On putting my ear over the sternum, a whistling respiratory sound was heard, and by means of the fluoroscope a shadow that might be caused by a nail was indistinctly outlined in the chest. The child was then anæsthetized by Dr. E. W. Whitney, and the accompanying radiograph taken. (Fig. 1.) It shows the head of the nail reaching down to the upper border of the seventh rib on the left side, the point reaching upward diagonally to the lower border of the fourth rib on the right side, hence the nail had entered the left bronchus head downward, and was lying behind the base of the heart

All the authorities consulted considered the removal of a foreign body from this location a very difficult problem, and gave a very high mortality.

Among other means for its removal, I thought of a magnet, and made inquiries of several so-called electricians to see if the idea were tenable, not knowing that any one else had attempted the magnet for this purpose. Recently I have noticed in the Annals of Surgery, December, 1902, that Dr. Brokaw, of St. Louis, had made an unsuccessful attempt to remove a tack by means of the

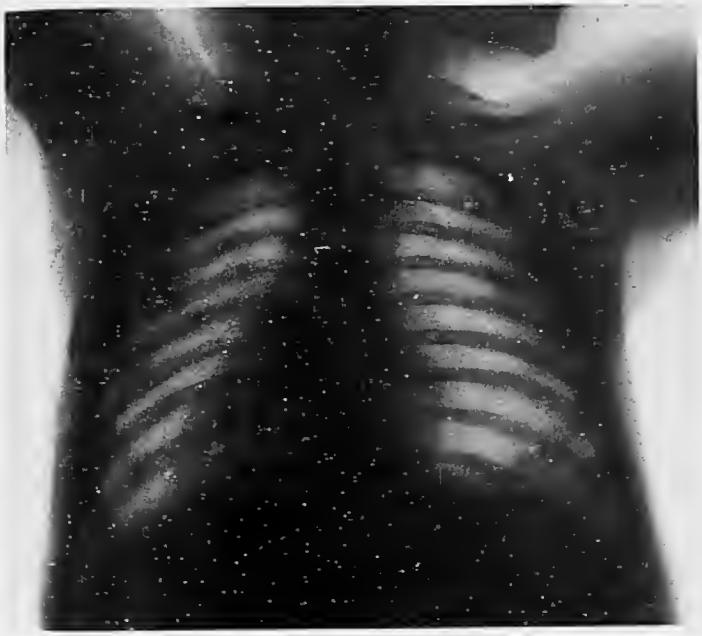

FIG. 1.—Shingle-nail lodged in bronchus.

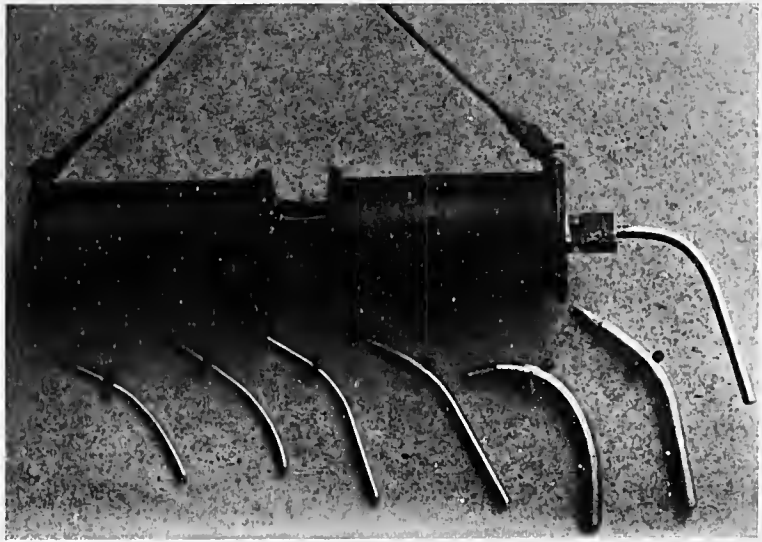

Fig. 2.—The Pfoutz-Godbe Magnet.

magnet from the bronchus of a child eight years old. But first to assure my skill in the mechanical method, I secured a dog, made a tracheotomy, put a shingle-nail head first into the bronchus, and attempted its removal by means of various ingenious instruments. I was unsuccessful; the dog died. I decided some other method must be used, and began to consider further the magnet. Dr. G. B. Pfoutz was consulted, to whom Dr. H. C. Deane presented a small electro-magnet secured from Dr. Baldwin, which Dr. Pfoutz took to Mr. Murray Godbe, an electric engineer with the Utah Light and Power Company, with whose collaboration was produced the electro-magnet shown in the accompanying picture. (Fig. 2.)

By means of this magnet, we were able to attract a shingle-nail for about two inches through space, and it required considerable force to detach it when once contact had occurred.

Accordingly, believing that this magnet would pull the nail from its bed in this little bronchial tube, on April 13, thirteen days after its lodging there, with Dr. Pfoutz's assistance, I made a low tracheotomy, and introduced the projecting tip of the magnet along the trachea down near to the point of the nail, and instantly, on the current being turned on, a distinct click, heard by all present, indicated that contact had occurred, and I gradually and carefully removed the magnet with the nail dangling on its point. I believe this to have been the first successful removal of a foreign body from a bronchial tube by means of a magnet. The wound was partially closed, and the child made an uninterrupted recovery.

We should be able to remove magnetic substances from the stomach and bladder by means of the electro-magnet, and it appears to me possible that in some cases, when the substance is in the trachea, or bronchi, a tracheotomy will not be necessary. The following description of the electro-magnet used in this case has been furnished by Mr. Godbe.

The magnet consisted of a Norway iron core, five-eighths of an inch in diameter and eleven inches long, on which was wound, in two sections, 6300 feet of No. 24 double cotton-covered magnet wire, making 9000 convolutions around the core, and having 160 ohms resistance.

It was designed for operation on 250 volt direct current, that

being the service available in your operating room. With that voltage there was passed one and one-half amperes of current, or 13,500 ampere turns around the magnet core. The end of the core was drilled and tapped to receive the Norway iron stems, a number of which were made in different sizes and shapes in order that you might select the one suitable for your operation. The one you selected and used in your operation was constructed of one-fourth inch Norway iron, and is the one attached to the magnet, and bent in the shape as shown in the photograph herewith. (Fig. 2.)

The number of magnetic lines that can be forced through a given cross-section of iron depends not only upon its quality or permeability, but upon its saturation. For instance, if a small number of lines are flowing through the iron at a given excitation, doubling the excitation will double the lines of force; when the lines reach a certain number, increasing the excitation does not proportionately increase the lines of force, and an excitation may be reached after which little, if any, increase of lines occurs with increased excitation.

Iron or steel used in magnetic circuits must be tested by sample before an accurate calculation can be made; and as the iron used in this magnet was no doubt thoroughly saturated, and also considering the magnetic leakage from the stem, accurate results as to the "pull" or "traction" of the magnet at its point could only be determined by actual measurement, which I find to be as follows: a lifting power at its point of 100 grammes, and a pull of ten grammes on the substance one-fourth inch from its point.

The use of this magnet in your operation has suggested to me the use of properly constructed electro-magnets in any case requiring the removal of magnetic substances from the body, and although my suggestion is along the line of the earliest discoveries, it might not be considered by those hurriedly called upon to construct a magnet for emergency use, as in your case, or those designing such a magnet in the shops.

We must conceive of a magnet in any shape having a definite circuit, that is, the lines of force passing from its north pole and entering its south pole. For many purposes this conception of poles is a very serviceable one: it is especially so when we have to treat of the influence which a magnet exerts throughout the space in its neighborhood, or throughout what is called the *magnetic field*. In this magnetic field the two poles will exert two forces,—one

tending to pull the particle towards it, and the other to push the particle from it. These two forces will have for their resultant a single force, which is the whole force exerted by the magnet on the particle, and will depend upon the amount of magnetic substance in the particle, and the number of magnetic lines embraced by the substance.

It will be seen, therefore, that any magnetic substance, to be attracted to the pole of the magnet, should be as near as possible in that portion of the magnetic field having the greatest magnetic density.

It has occurred to me that a large and powerful electro-magnet could be constructed and mounted so as to be easily placed in any position relative to the body being operated upon, and having different sizes and lengths of flexible iron stems, attachable to the magnet core, for insertion into wounds or parts of the body for the removal of foreign magnetic substances. If this magnet is so placed that the point of its stem and the substance to be removed will be in the field of greatest density, I believe satisfactory results can be obtained.